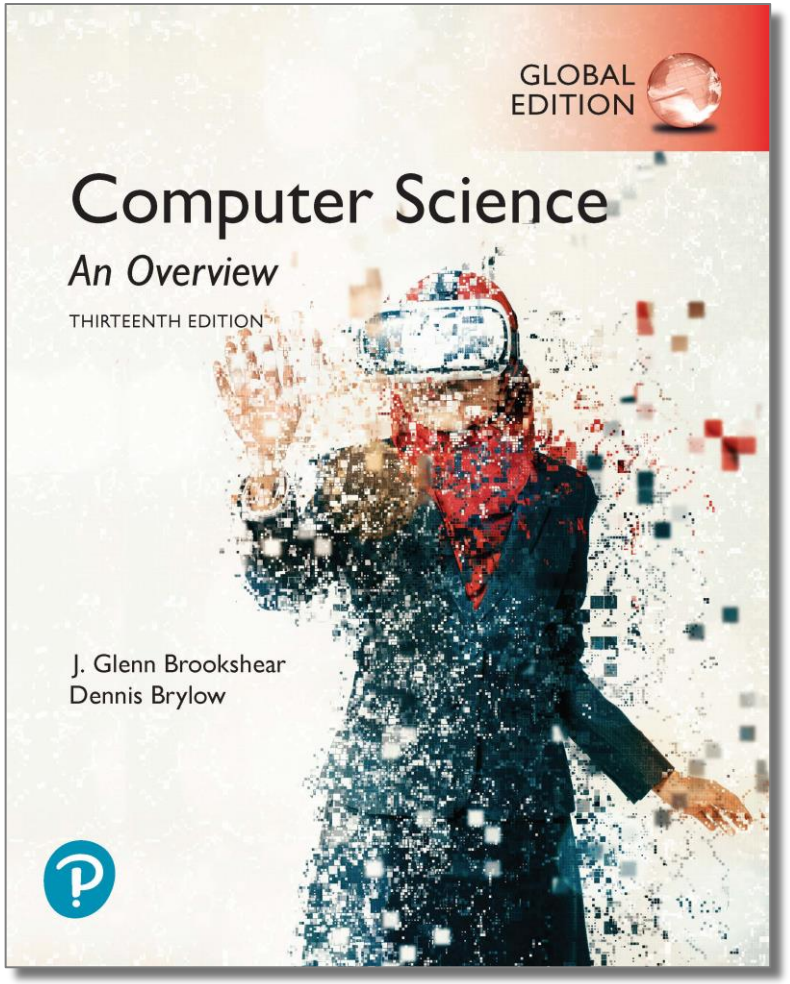
Computer Science An Overview

13th Edition, Global Edition



Chapter 4

Networking and the Internet

Chapter 4: Networking and the Internet

- 4.1 Network Fundamentals
- 4.2 The Internet
- 4.3 The World Wide Web
- 4.4 Internet Protocols
- 4.5 Simple Client Server
- 4.6 Security

4.1 Network Fundamentals

- Network Software allows users to exchange information and share resources
  - Content
  - Software
  - Data storage facilities
- Network software has evolved into a network-wide operating system

Network Classifications

- Scope
  - Personal Area Network (short-range)
  - Local Area Network (building/campus)
  - Metropolitan Area Network (community)
  - Wide Area Network (greater distances)
- Ownership
  - Closed versus open
- Topology (configuration)
  - Bus (Ethernet)
  - Star (Wireless networks with central Access Point)

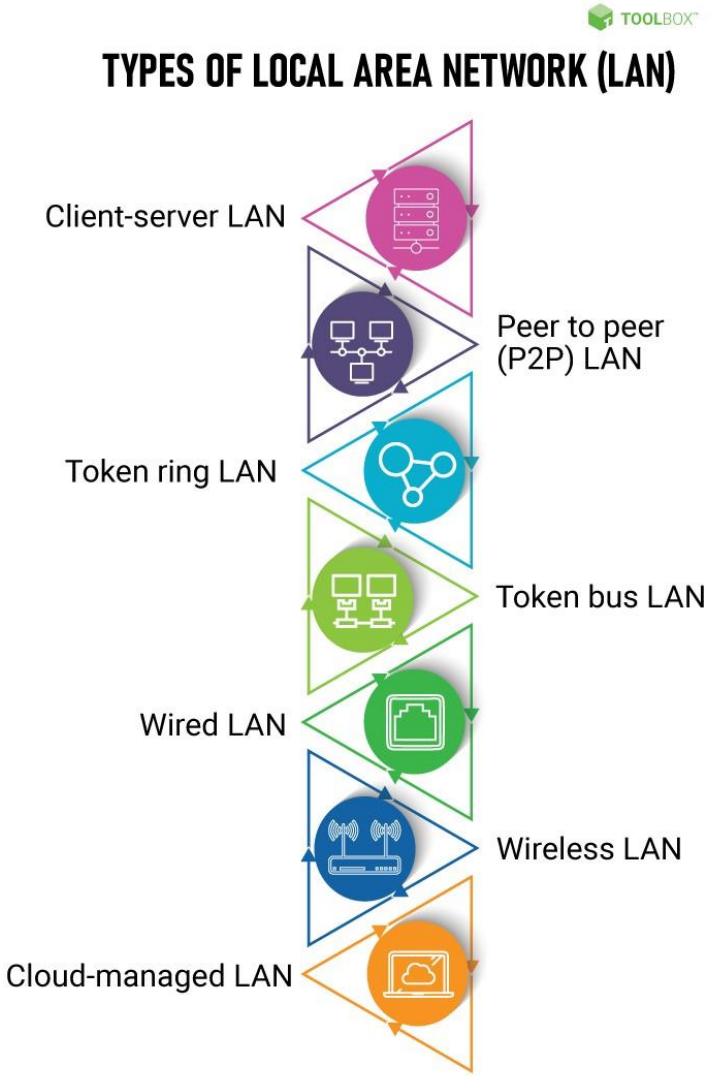
Personal Area Network

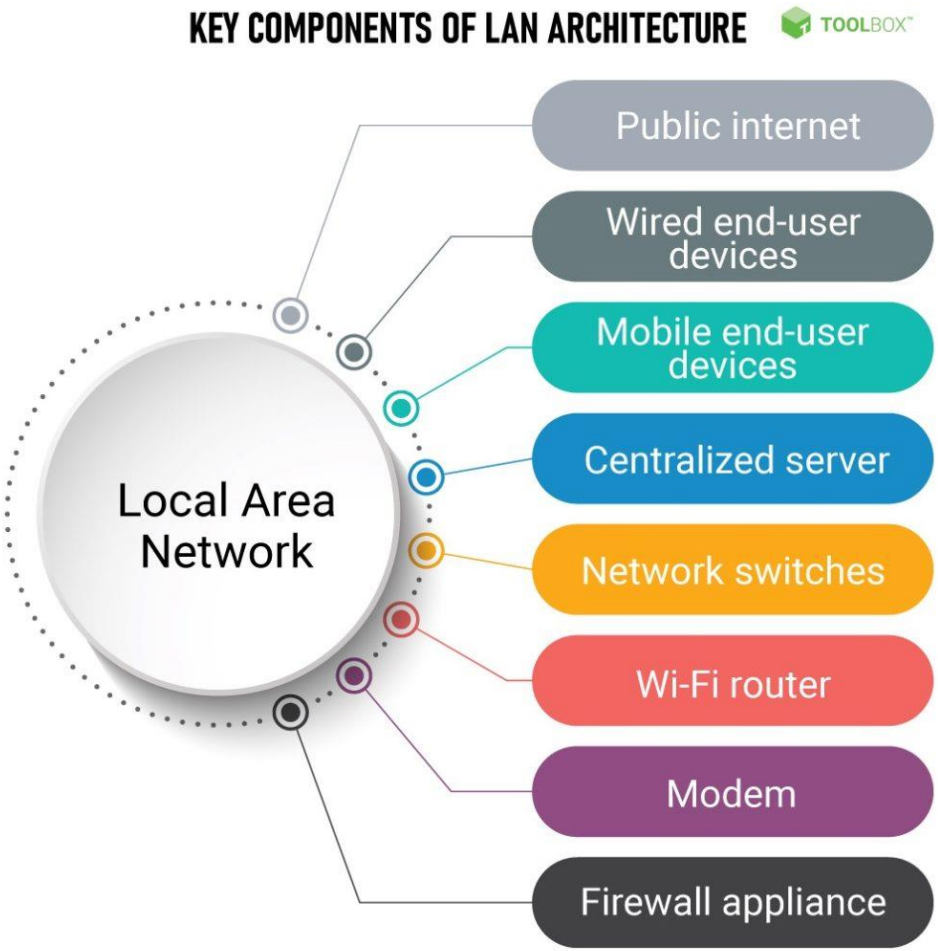
●表 短距離無線通訊與新興通訊技術比較表

無線通訊技術	Bluetooth 藍牙	ANT	ZigBee	NFC (Near Field Communication)	UWB (ultra-wideband)	TransferJet	IrDA (Infrared Data Association)	Li-Fi (Light Fidelity)
協會Logo						TransferJet		(非正式Logo)
正式出道時間	1999	2004	2005	2004	2002	2008	1993	2011
傳輸距離(米)	10~100 (一般模式) 10~30 (BLE)	0~30	10~75 (一般模式) 134 (降到28kbps時)	0~0.2	0~10	0~0.03	0.2~1 (Angle < 30°)	0~5
傳輸速度	1~3Mbps (一般模式) 24Mbps (Bluetooth HS)	20Kbps	10kbps~250Kbps	106Kbps 212Kbps 424Kbps	53.3~480Mbps	375~560Mbps	9.6K~115.2Kbps (SIR) 4M/16Mbps (FIR/VFIR)	1.6Gbps per 1-color LED
傳輸技術	無線電 射頻	無線電 射頻	無線電 射頻	無線電 射頻	無線電 射頻	電感磁場	光通訊 (紅外線)	光通訊 (可見光)
使用頻段	2.4GHz	2.4GHz 1GHz (頻道擁塞時)	2.4GHz 915MHz (北美) 868MHz (歐洲)	13.56MHz	3.1GHz~10.6GHz	4.48GHz	300GHz~400THz (使用紅外線頻段, 波長850~900nm)	400~800THz (使用可見光頻譜, 波長375~780nm)
安全性	高	高	中	極高	高	極高	低	中
國際標準	IEEE 802.15.1	Proprietary	IEEE 802.15.4	ISO/IEC 18092 ECMA 340 ETSI TS 102 190	IEEE 802.15.3a ECMA 368 ISO/IEC 26907~8	Proprietary	Proprietary	Proprietary
延伸規格	Bluetooth Smart (BLE) Bluetooth HS	ANT+	ZigBee RF4CE (2009)	NFC爲RFID的延伸分支	N/A	N/A	VFIR, UFIR, GigaIR, 5/10GigaIR	基於VLC協會的 IEEE 802.15.7
網路拓撲	廣播,網狀,星狀,掃描,點對點	廣播,網狀,星狀,掃描,點對點	網狀,星狀,掃描,點對點	點對點	點對點	點對點	點對點	星狀,點對點
應用範圍 (用途)	手機, 平板, 遊戲機, 耳機,立體聲音頻串流, 汽車, 電腦及週邊, 穿戴式裝置 (資料傳輸, 同步, 音訊串流,物聯網)	手錶, 體育健身, 醫療保健, 穿戴式裝置 (同步, 資料傳輸,物聯網)	遠端監控/遙控, 燈具控制, 各種自動化, 無線感應網路, 穿戴式裝置 (遙控, 資料傳輸,物聯網)	手機, 各式ICT產品, 穿戴式裝置, 電子錢包 (身份辨識, 認證,資料傳輸, 電子支付)	電腦及週邊 (資料傳輸, 同步, 視訊串流)	相機, 電腦週邊, 行動裝置, 手機, USB同步底座 (同步,資料傳輸, 視訊串流)	手機, 平板, 遊戲機, 耳機, 電視, 電腦及週邊 (遙控, 資料傳輸, 同步)	各 ICT產品, 海底環境/低電磁波干擾環境 (資料傳輸, 上網, 視訊串流)
主管協會/單位	Bluetooth SIG	ANT+ Alliance	ZigBee Alliance	NFC Forum	WiMedia Alliance (已解散, 於2009技轉給Bluetooth SIG, USB-IF)	TransferJet Consortium	Infrared Data Association	Li-Fi Consortium
網站	www.bluetooth.org	www.thisisant.co	www.zigbee.org	www.nfc-forum.org	www.wimedia.org	www.transferjet.org	www.irda.org	www.lificonsortium.org

資料來源: DIGITIMES整理，2014/4

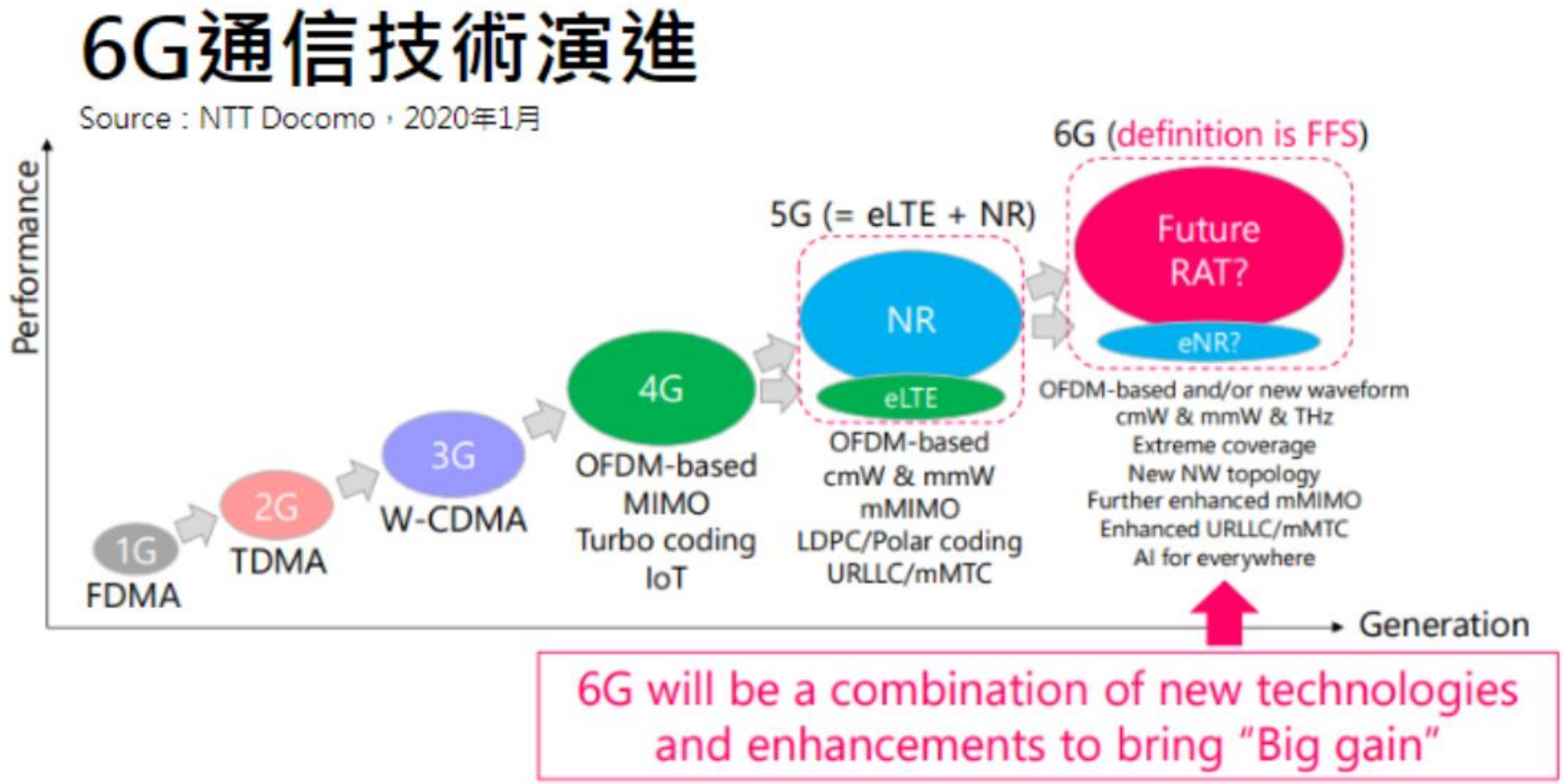
Local Area Network





Metropolitan Area Network

Metropolitan Area Network



Wide Area Network

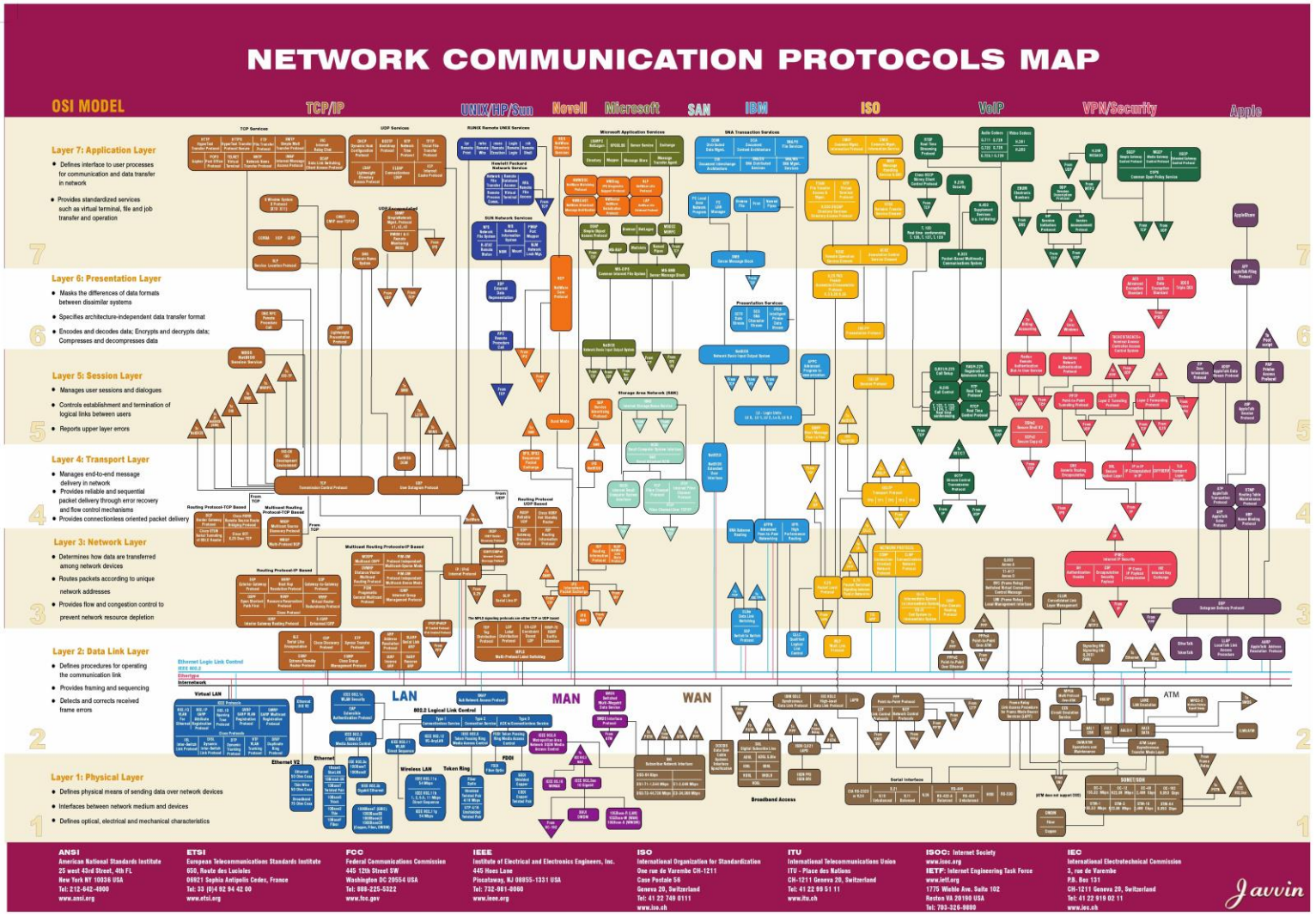


Figure 4.1 Two popular network topologies (1 of 2)

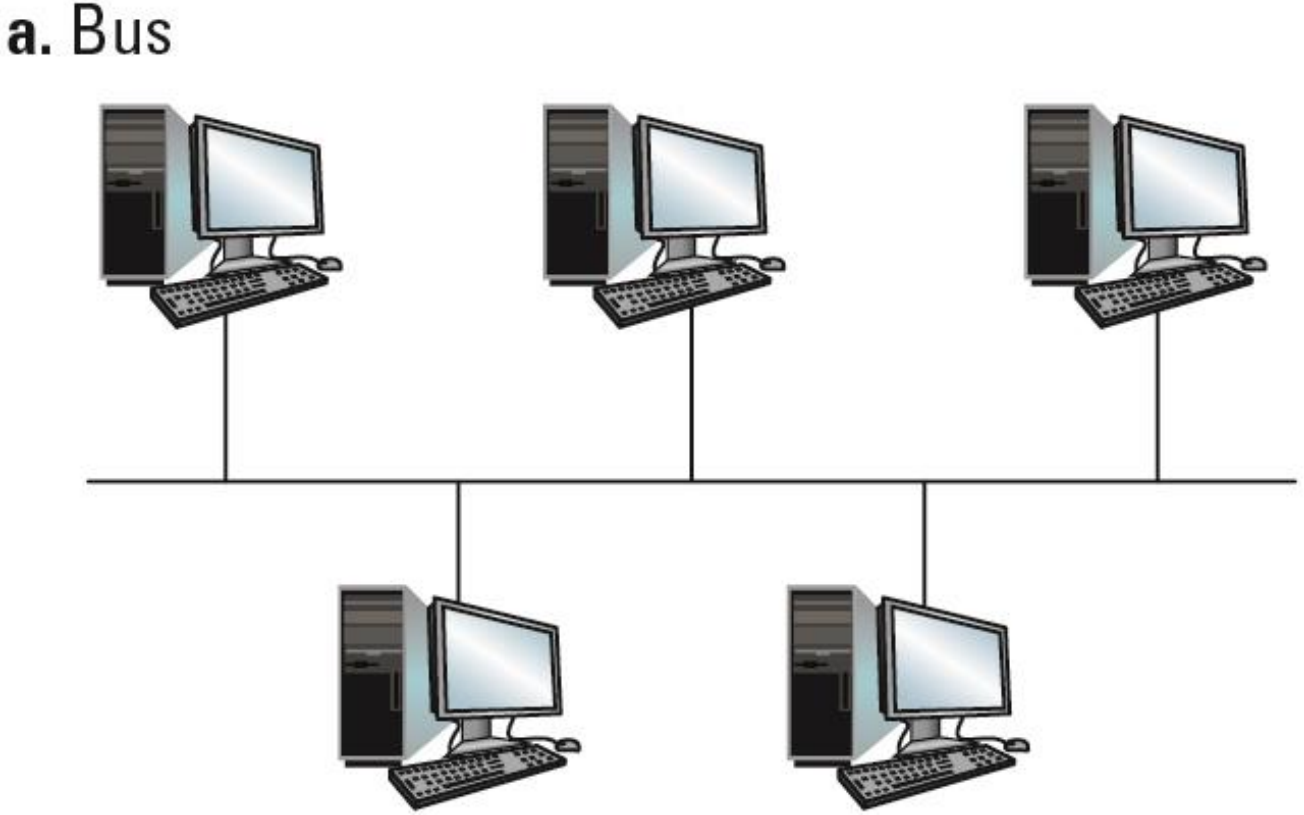
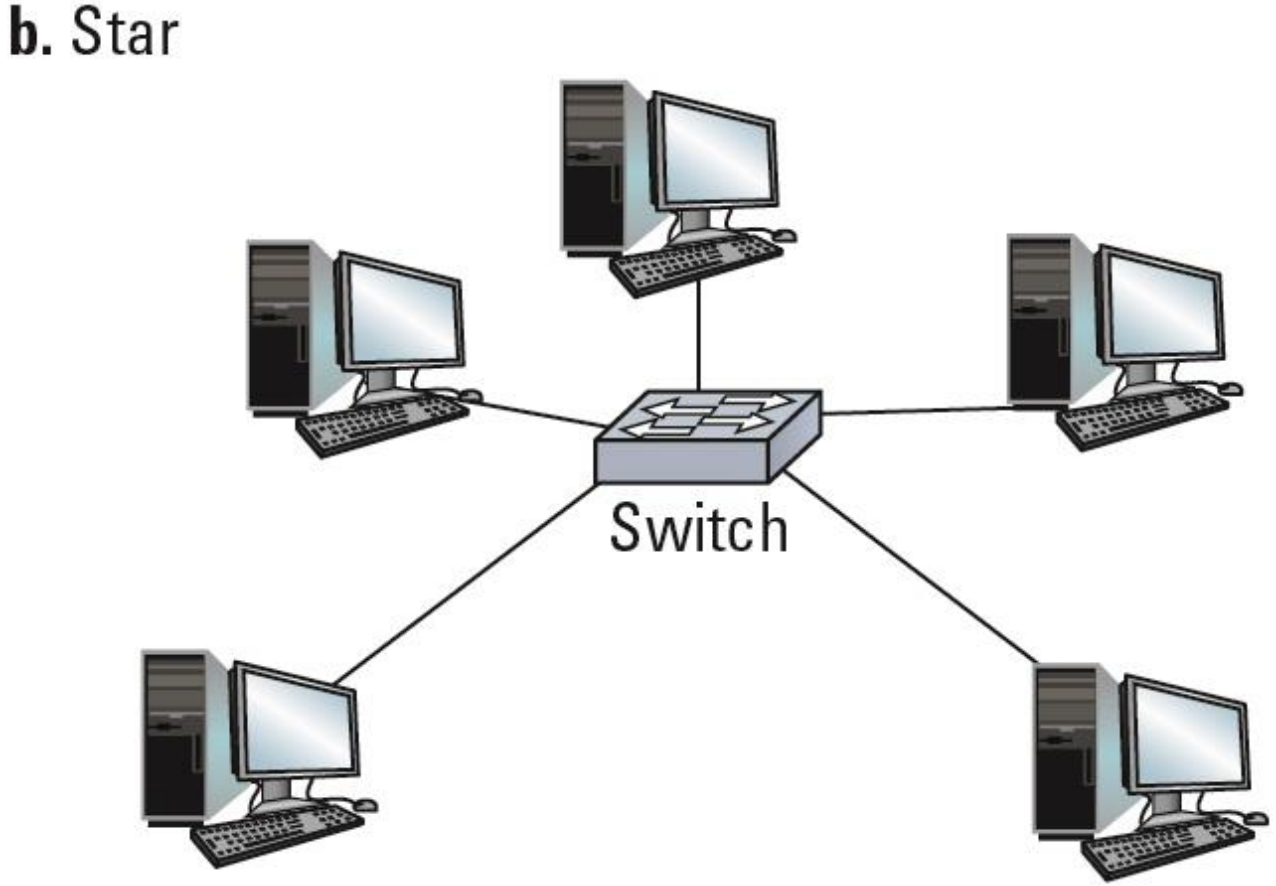


Figure 4.1 Two popular network topologies (2 of 2)



Protocols

- Rules by which activities are conducted on a network
  - Example: Coordinating the transmission of messages between computers
    - Need to avoid all machines transmitting at the same time
- Allows vendors to build products that are compatible with products from other vendors

Protocols for Transmitting Messages

- CSMA/Collision Detection
  - used in Ethernet
  - both machines stop and wait for a independent, random time
- CSMA/Collision Avoidance
  - used in WiFi, where not all machines can hear each other (hidden terminal problem)
  - give advantage to the machine that has already been waiting

Figure 4.2 Communication over a bus network

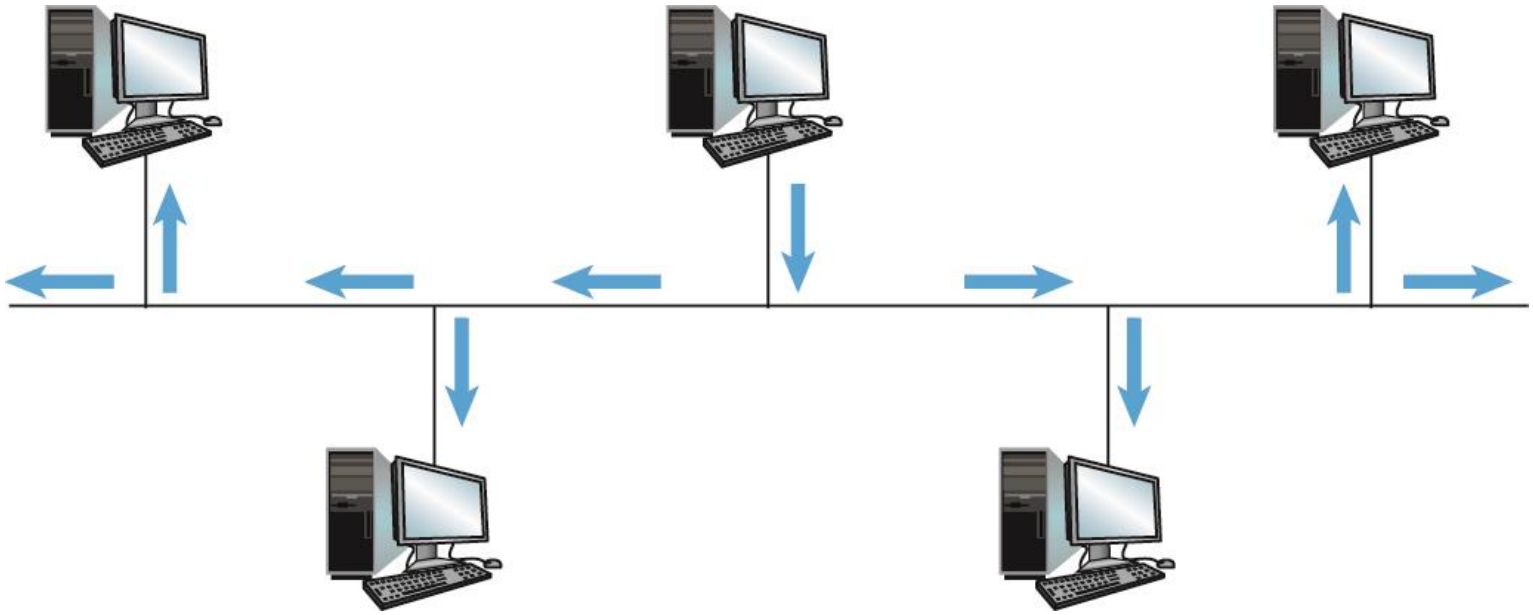
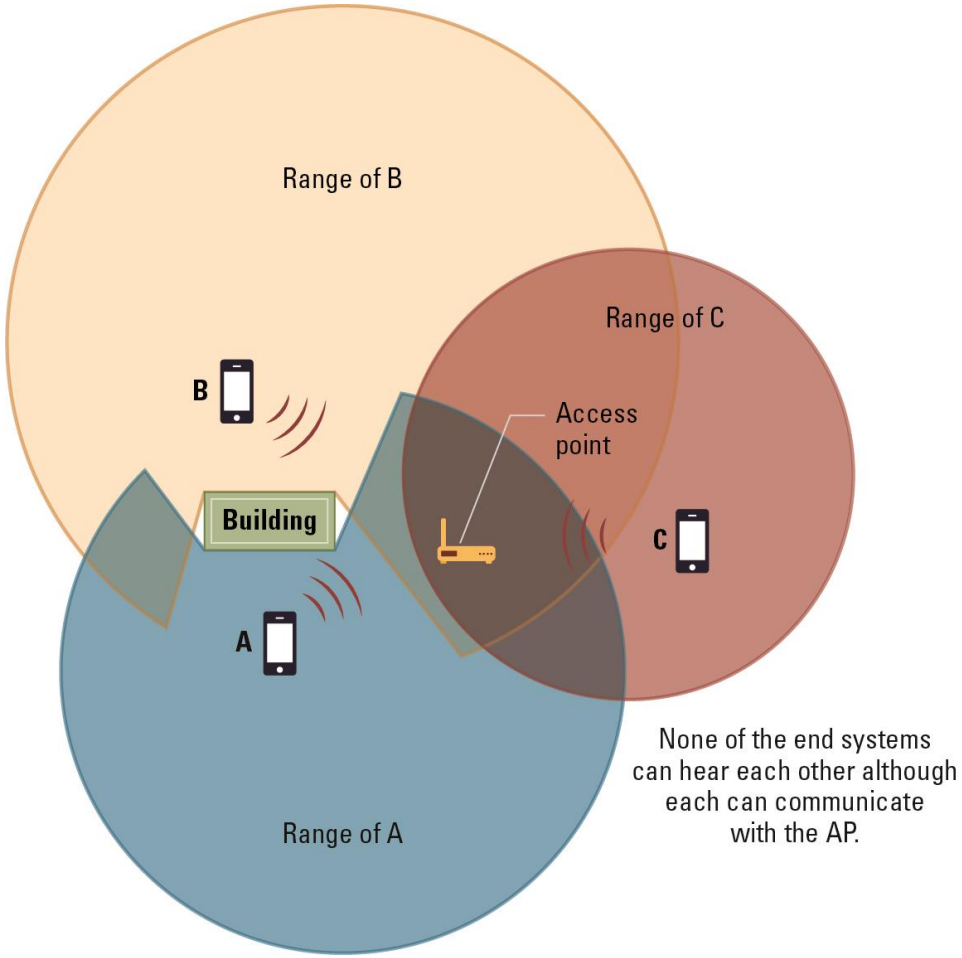


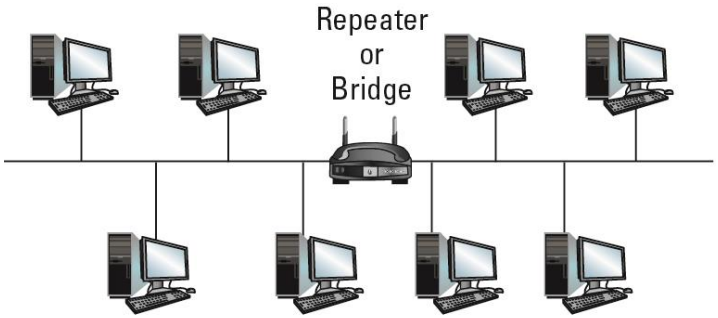
Figure 4.3 The hidden terminal problem



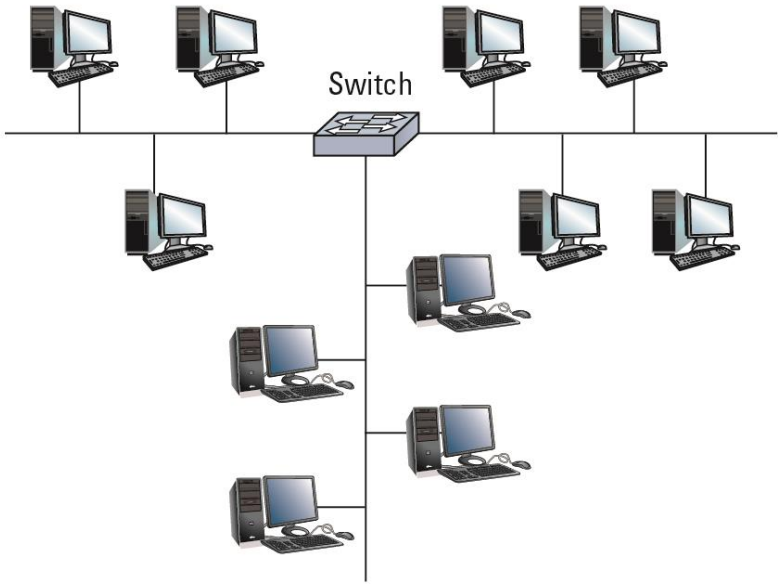
Combining Networks

- **Repeater:** passes all messages across two busses
- **Bridge:** passes only messages that are destined for computers on the other bus
- **Switch:** acts like a bridge, but with connections to multiple busses
- **Router:** Connects two incompatible networks
  resulting in a network of networks called an **internet**

Figure 4.4 Building a large bus network from smaller ones

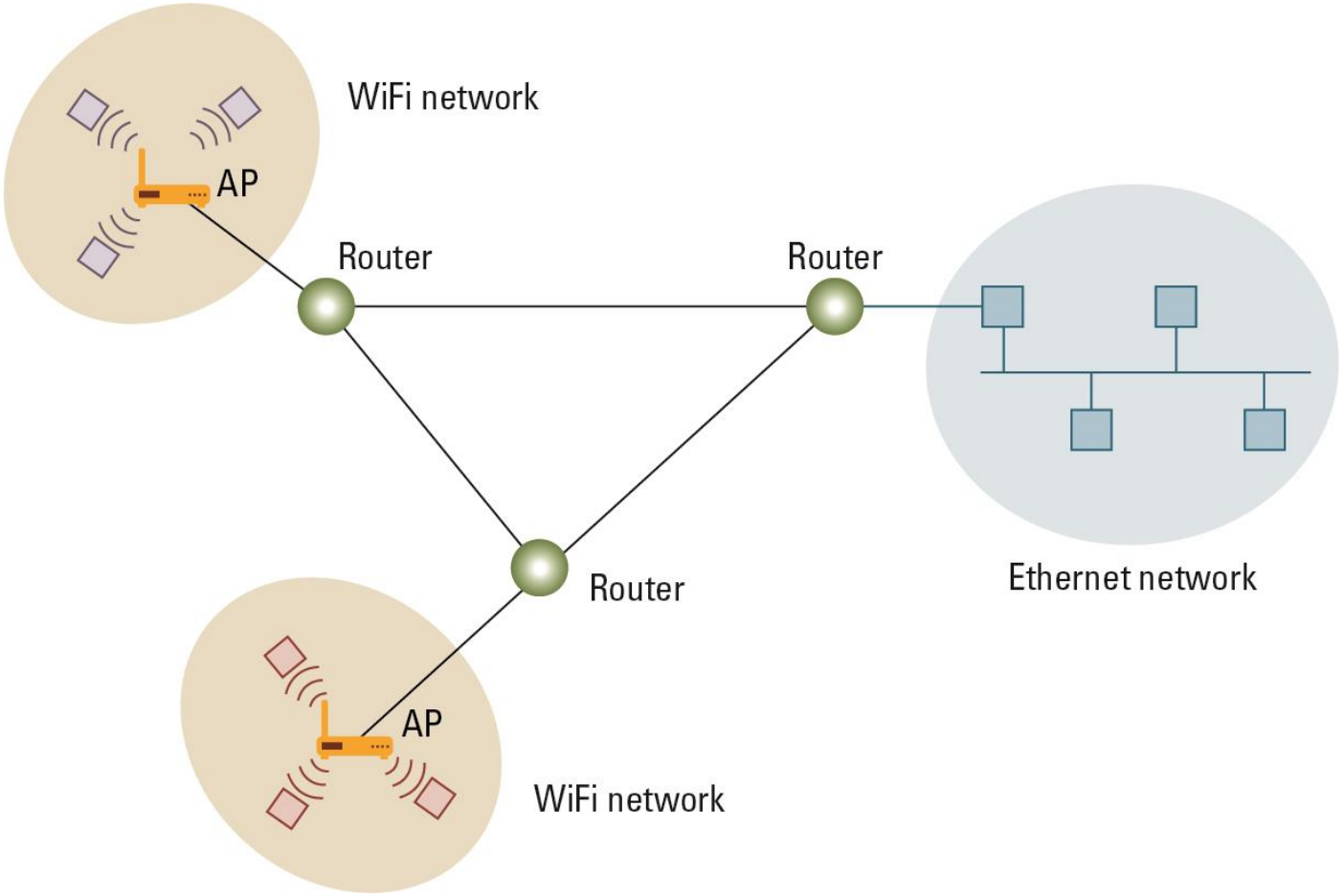


a. A repeater or bridge connecting two buses



b. A switch connecting multiple buses

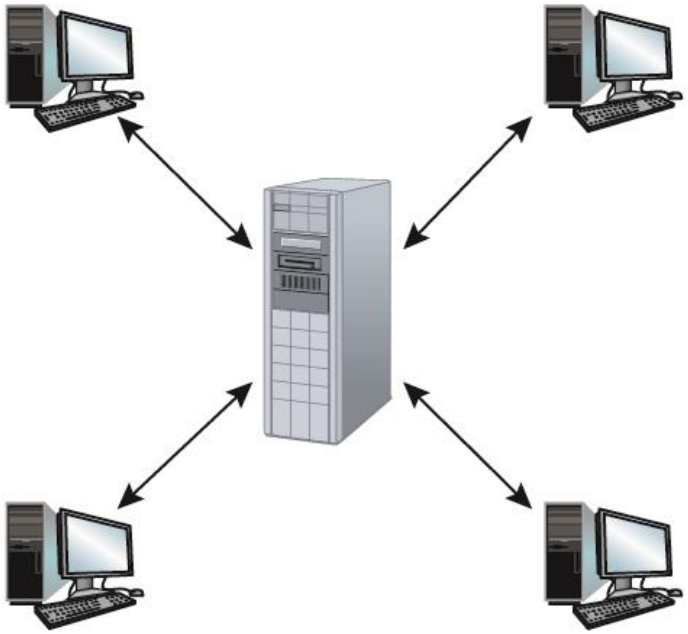
Figure 4.5 Routers connecting two WiFi networks and an Ethernet network to form an internet



Methods of Process Communication

- Client-server
  - Many clients, one server (executing continuously)
  - Clients make requests of other processes
  - Server satisfies requests made by clients
- Peer-to-peer (P2P)
  - Two processes communicating as equals
  - Processes execute on a temporary basis

Figure 4.6 The client/server model compared to the peer-to-peer model



a. Server must be prepared to serve multiple clients at any time.

b. Peers communicate as equals on a one-to-one basis.

Distributed Systems

- Systems units that execute as processes on different computers
  - Cluster computing 1980
    - Independent computers work closely together instead of a single, much larger machine
  - Grid computing 1990
    - Millions of home PCs (not connected to each other) work on a complex problem
  - Cloud computing 2007
    - Provide services, hide the details

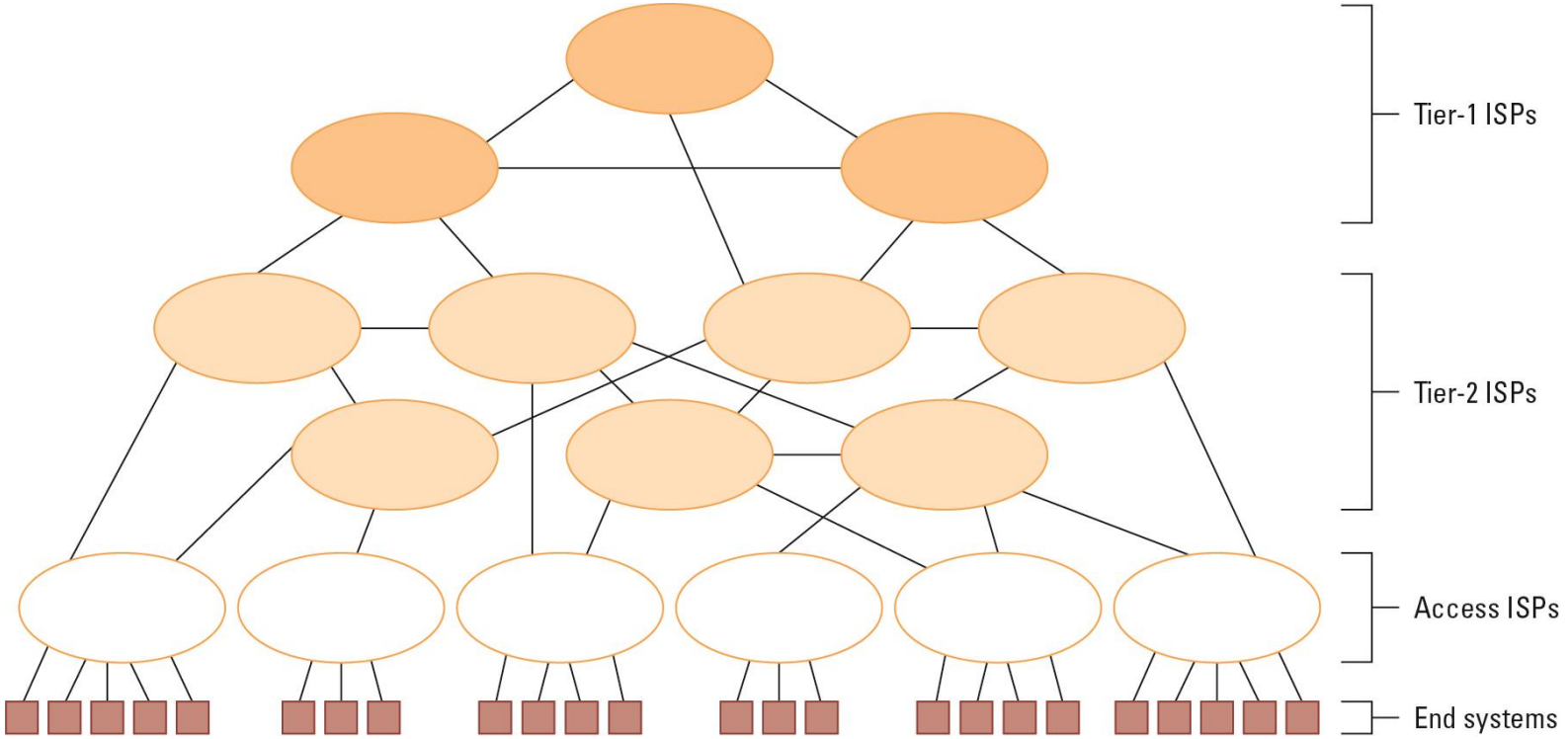
4.2 The Internet

- The Internet is an internet that spans the world
  - Original goal was to link a variety of networks into a connected system unaffected by local disasters
  - Today, it is a commercial undertaking that links a worldwide combination of PANs, LANs, MANs, and WANs involving millions of computers

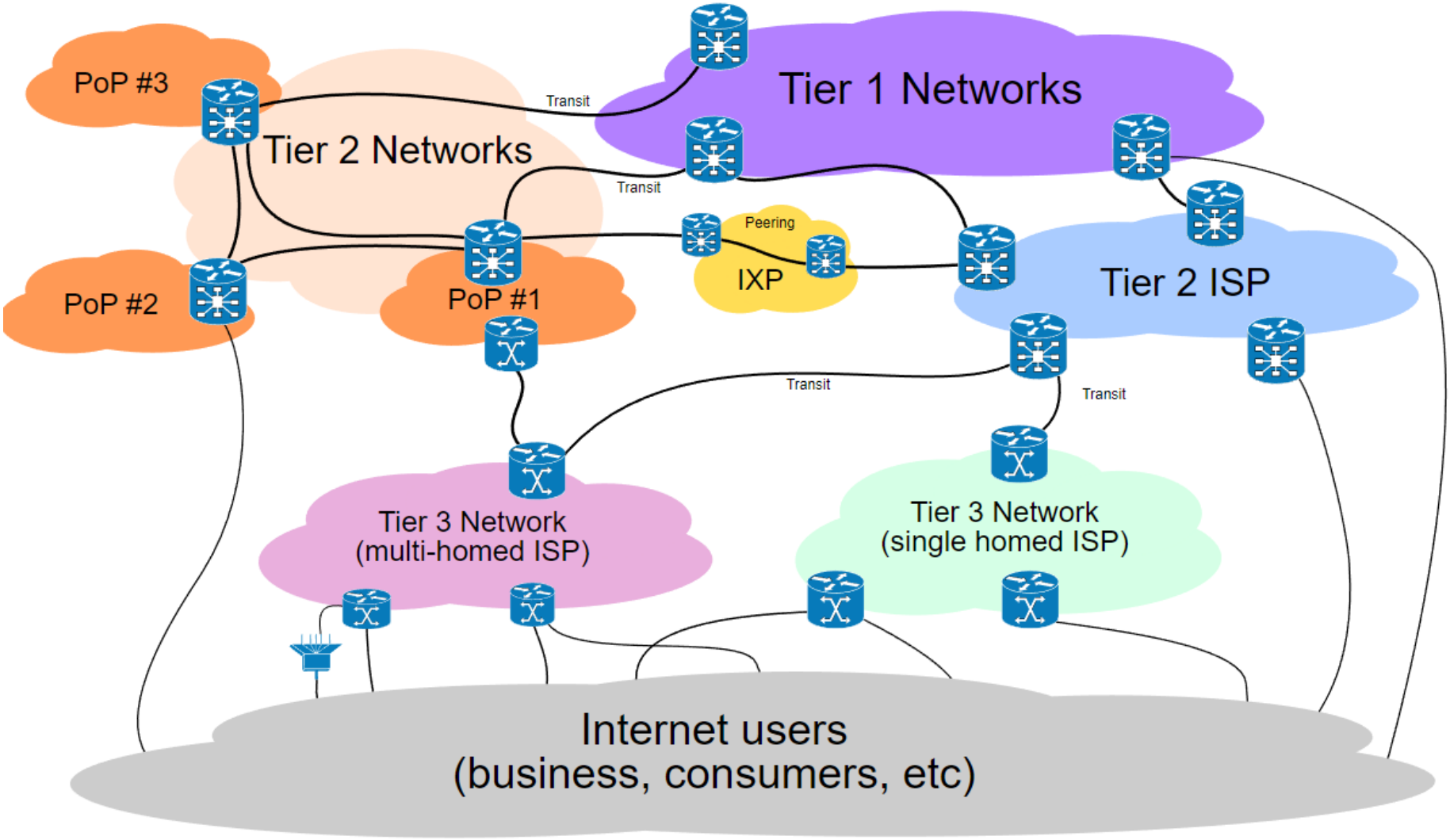
Internet Architecture

- Internet Service Provider (ISP)
  - Tier-1 (Internet backbone)
  - Tier-2
- Access or Tier-3 ISP: Provides connectivity to the Internet
  - Hot spot (wireless)
  - Telephone lines
  - Cellular
  - Cable/Satellite systems

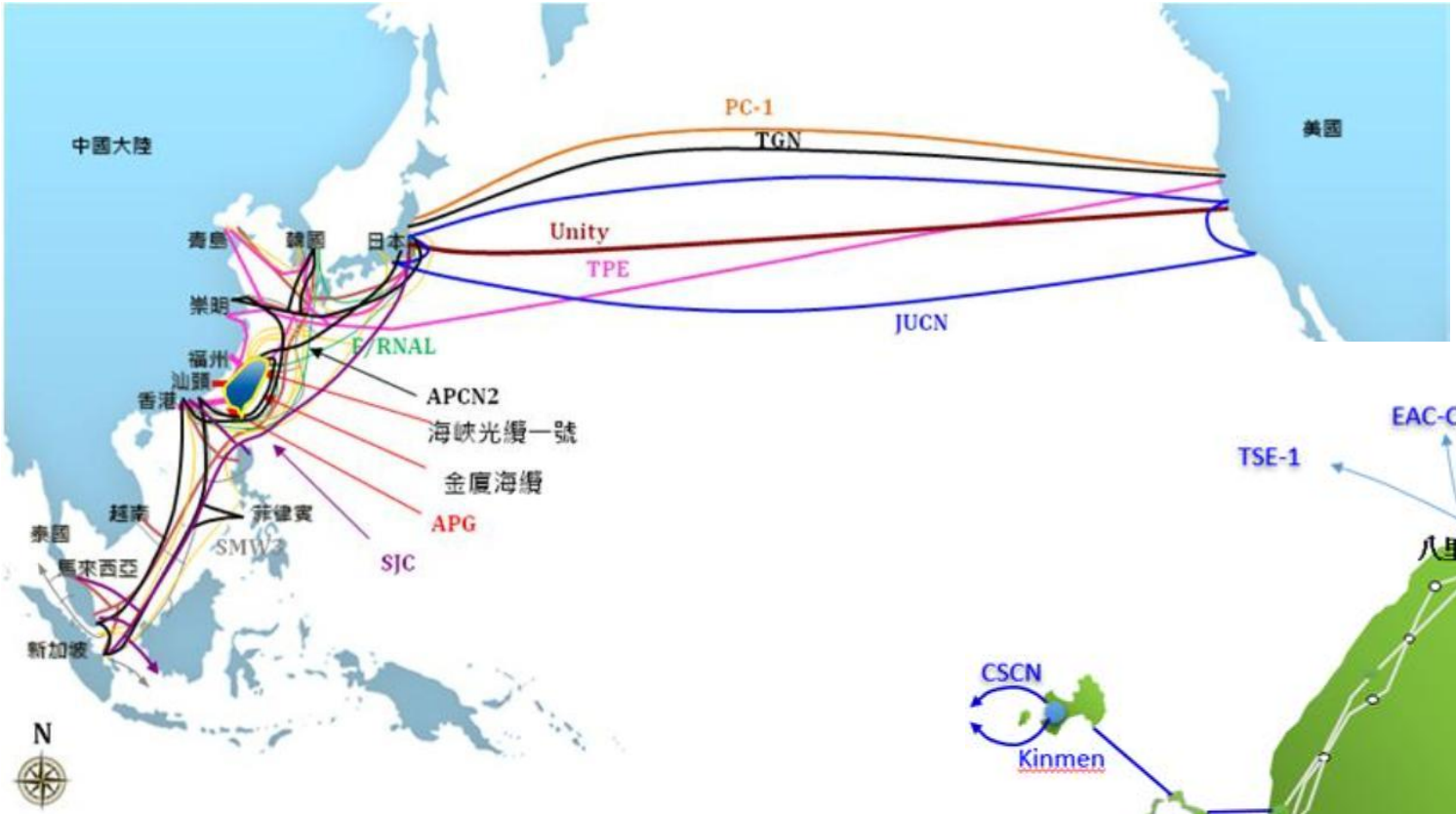
Figure 4.7 Internet Composition

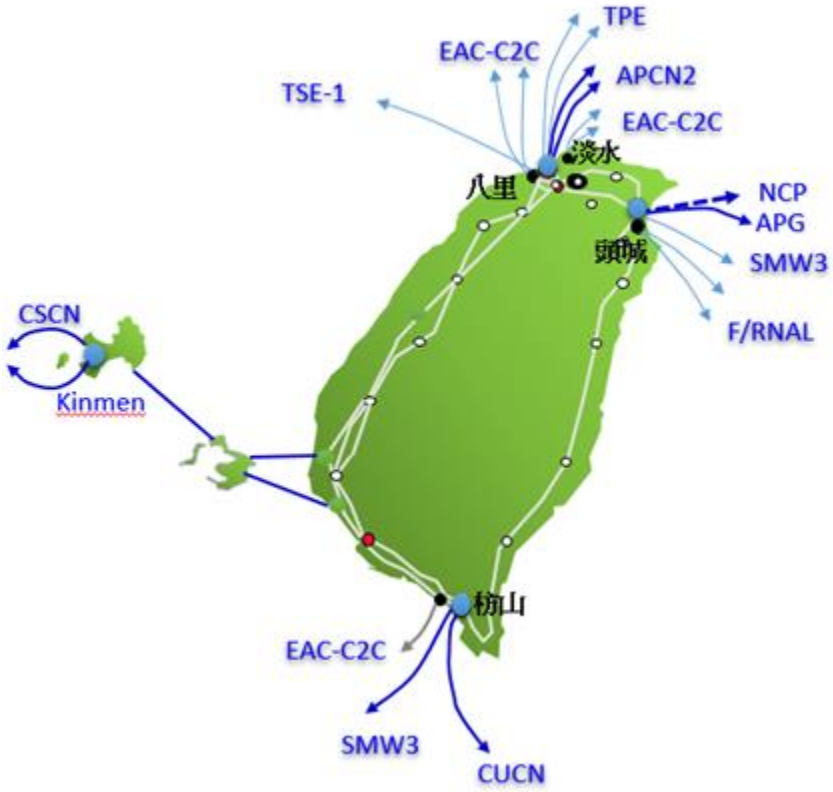


Internet Architecture

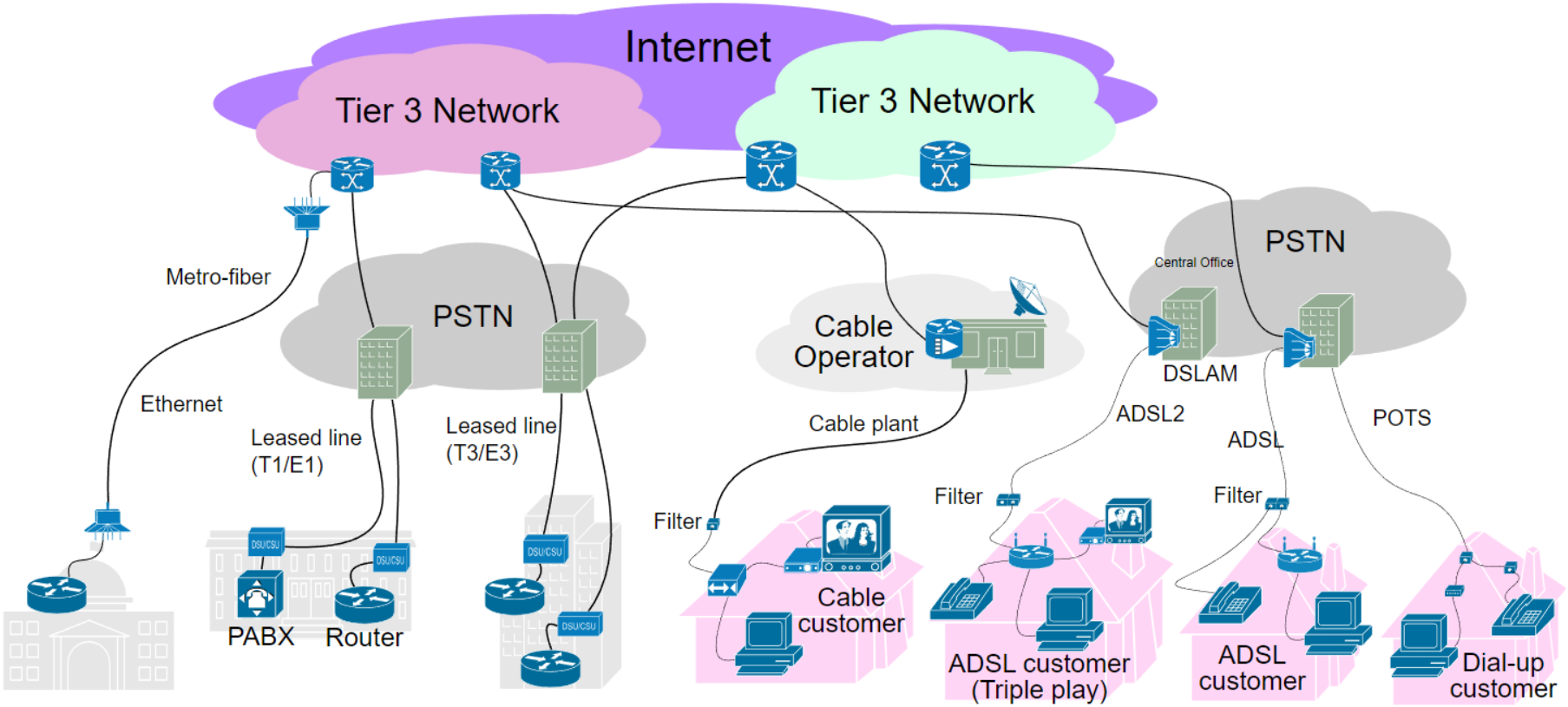


Internet Architecture





Internet Architecture



Internet Addressing

- IP address: pattern of 32 or 128 bits often represented in dotted decimal notation
- Mnemonic address:
  - Domain names (ncku.edu.tw)
  - Top-Level Domains
    - .org, .gov, .com, .mil, .net, .au, .ca, .biz, ….
- Domain name system (DNS)
  - Name servers
  - DNS lookup

Internet Corporation for Assigned Names & Numbers (ICANN)

- Allocates blocks of IP addresses to ISPs who then assign those addresses within their regions.
- Oversees the registration of domains and domain names.

Early Internet Applications

- Network News Transfer Protocol (NNTP)
- File Transfer Protocol (FTP)
- Telnet and Secure Shell (SSH)
- Hypertext Transfer Protocol (HTTP)
- Electronic Mail (email)
  - Domain mail server collects incoming mail and transmits outing mail
  - Mail server delivers collected incoming mail to clients via POP3 or IMAP

SMTP Simple Mail Transfer Protocol

```
220 mail.tardis.edu SMTP Sendmail Gallifrey-1.0; Fri, 23 Aug 2413
14:34:10
HELO mail.skaro.gov
250 mail.tardis.edu Hello mail.skaro.gov, pleased to meet you
MAIL From: dalek@skaro.gov
250 2.1.0 dalek@skaro.gov... Sender ok
RCPT To: doctor@tardis.edu
250 2.1.5 doctor@tardis.edu... Recipient ok
DATA
354 Enter mail, end with "." on a line by itself
Subject: Extermination.

EXTERMINATE!
Regards, Dalek
.
250 2.0.0 r7NJYAEl028071 Message accepted for delivery
QUIT
221 2.0.0 mail.tardis.edu closing connection
```

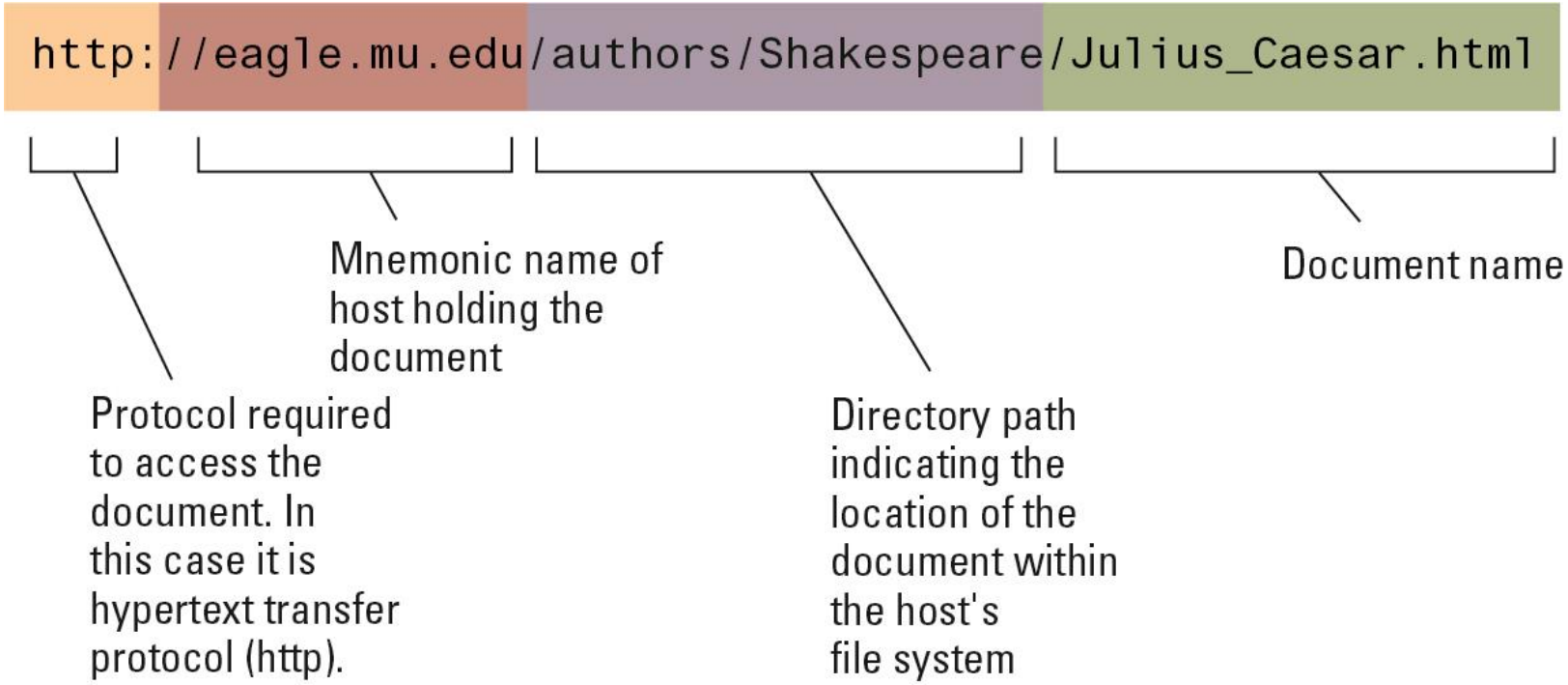
More Recent Applications

- Voice Over IP (VoIP)
- Internet Multimedia Streaming
  - N-unicast
  - Multicast
  - On-demand streaming
  - Content delivery networks (CDNs)

4.3 World Wide Web

- **Hypertext** combines internet technology with concept of linked-documents
  - Embeds **hyperlinks** to other documents
- **Browsers** present materials to the user
- **Webservers** provide access to documents
- Documents are identified by **URL**s and transferred using **HTTP**

Figure 4.8 A typical URL



Hypertext Markup Language (HTML)

- Encoded as text file
- Contains tags to communicate with browser
  - Appearance
    - <h1> to start a level one heading
    - <p> to start a new paragraph
  - Links to other documents and content
    - <a href = . . . >
  - Insert images
    - <img src = . . . >

Figure 4.9 A simple webpage

a. The page encoded using HTML.

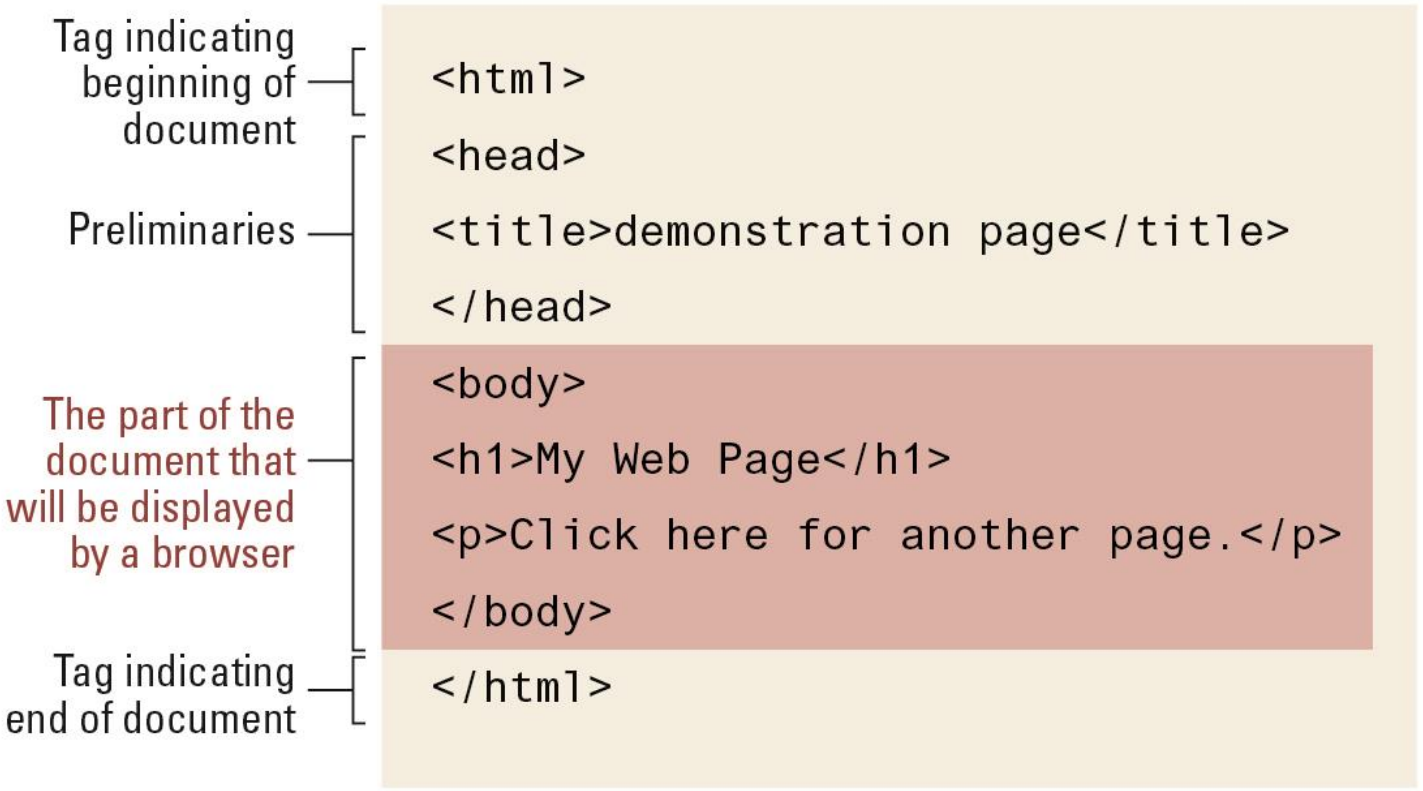


Figure 4.9 A simple webpage (continued)

b. The page as it would appear on a computer screen.

Figure 4.10 An enhanced simple webpage

a. The page encoded using HTML.

Figure 4.10 An enhanced simple Web page (continued)

b. The page as it would appear on a computer screen.

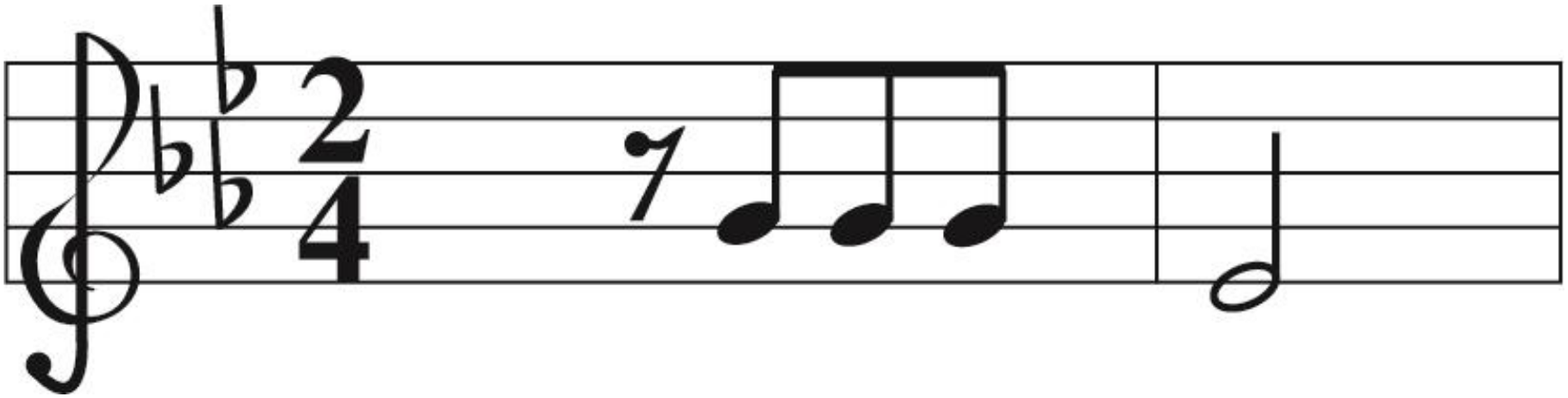
Extensible Markup Language (XML)

- XML: A language for constructing markup languages similar to HTML
  - A descendant of the Standard Generalized Markup Language
  - Opens door to a World Wide *Semantic* Web

Using XML to encode music

```
<staff clef = “treble”> <key>C minor</key>

<time> 2/4 </time>

<measure> < rest> egth </rest> <notes> egth G,
   egth G, egth G  </notes></measure>

<measure> <notes> hlf E </notes></measure>

</staff>
```

Figure 4.11 The first two bars of Beethoven's Fifth Symphony



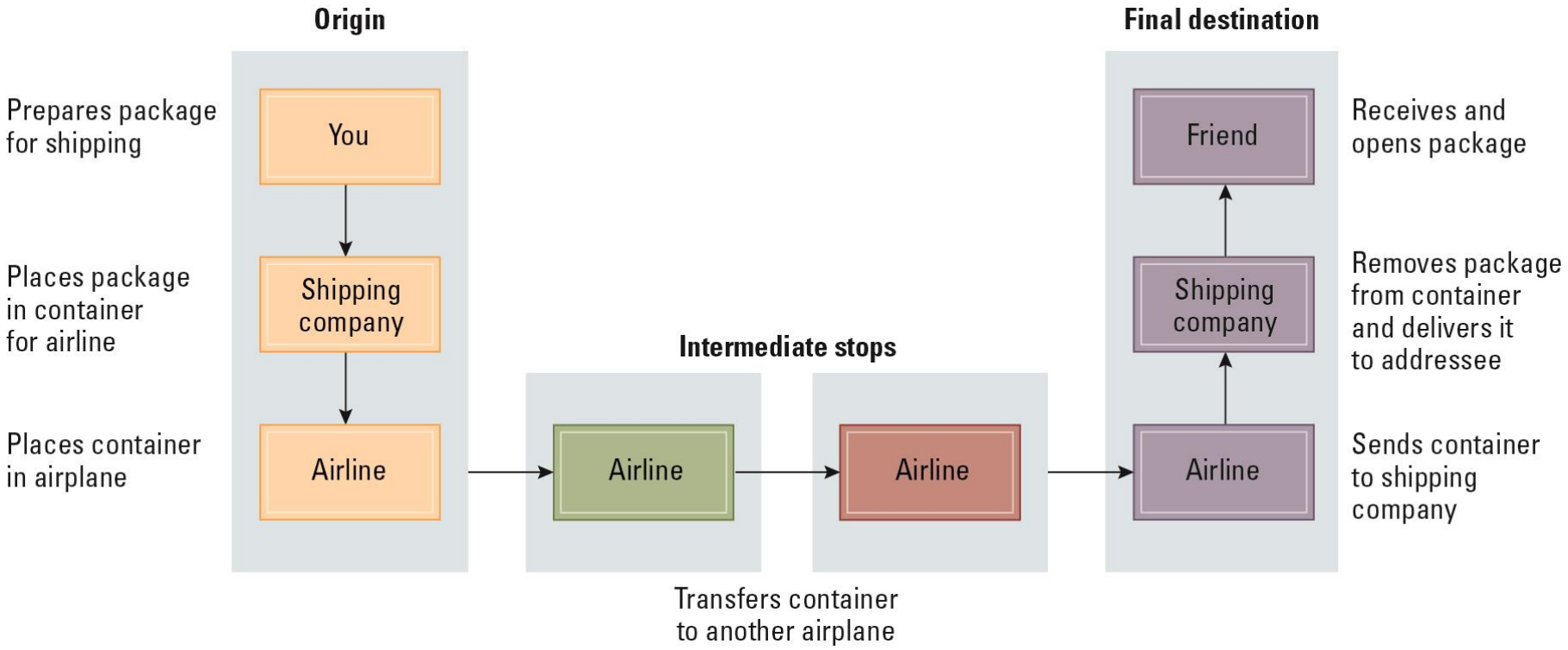
Client Side Versus Server Side

- Client-side activities (browser)
  - Javascript
  - Java applets
  - Macromedia Flash
- Server-side activities (webserver)
  - Common Gateway Interface (CGI)
  - Servlets
  - JavaServer Pages (JSP) / Active Server Pages (ASP)
  - PHP

4.4 Internet Protocols

- Control how messages are transferred over the Internet
- This software must reside on every computer in the Internet
- Accomplished by a multi-level hierarchy

Figure 4.12 Package-shipping example



Internet Software Layers

- **Application:** Constructs message with address
- **Transport:** Chops message into packets
- **Network:** Handles routing through the Internet
- **Link:** Handles actual transmission of packets

Figure 4.13 The Internet software layers

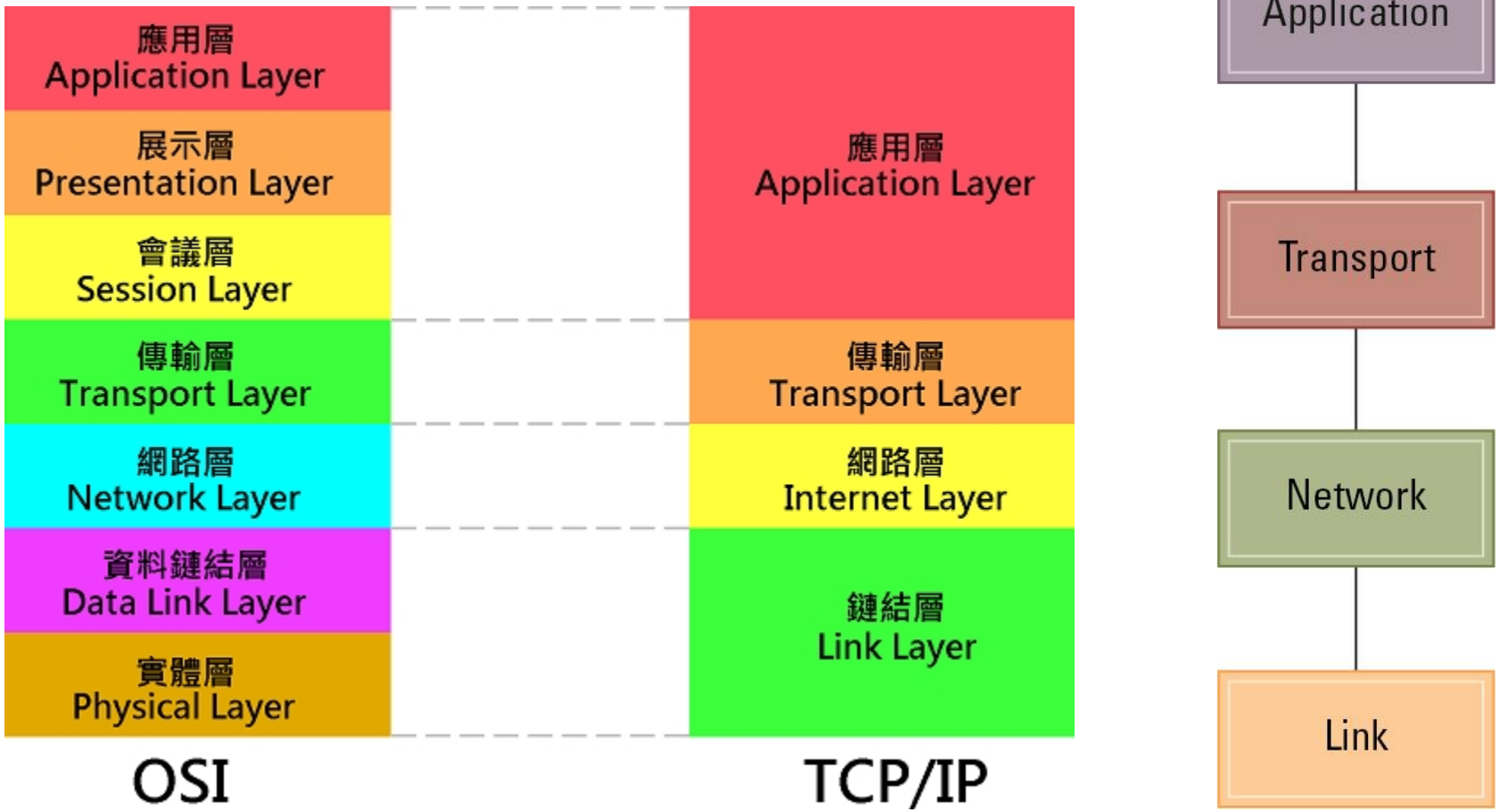


Figure 4.14 Following a message through the Internet

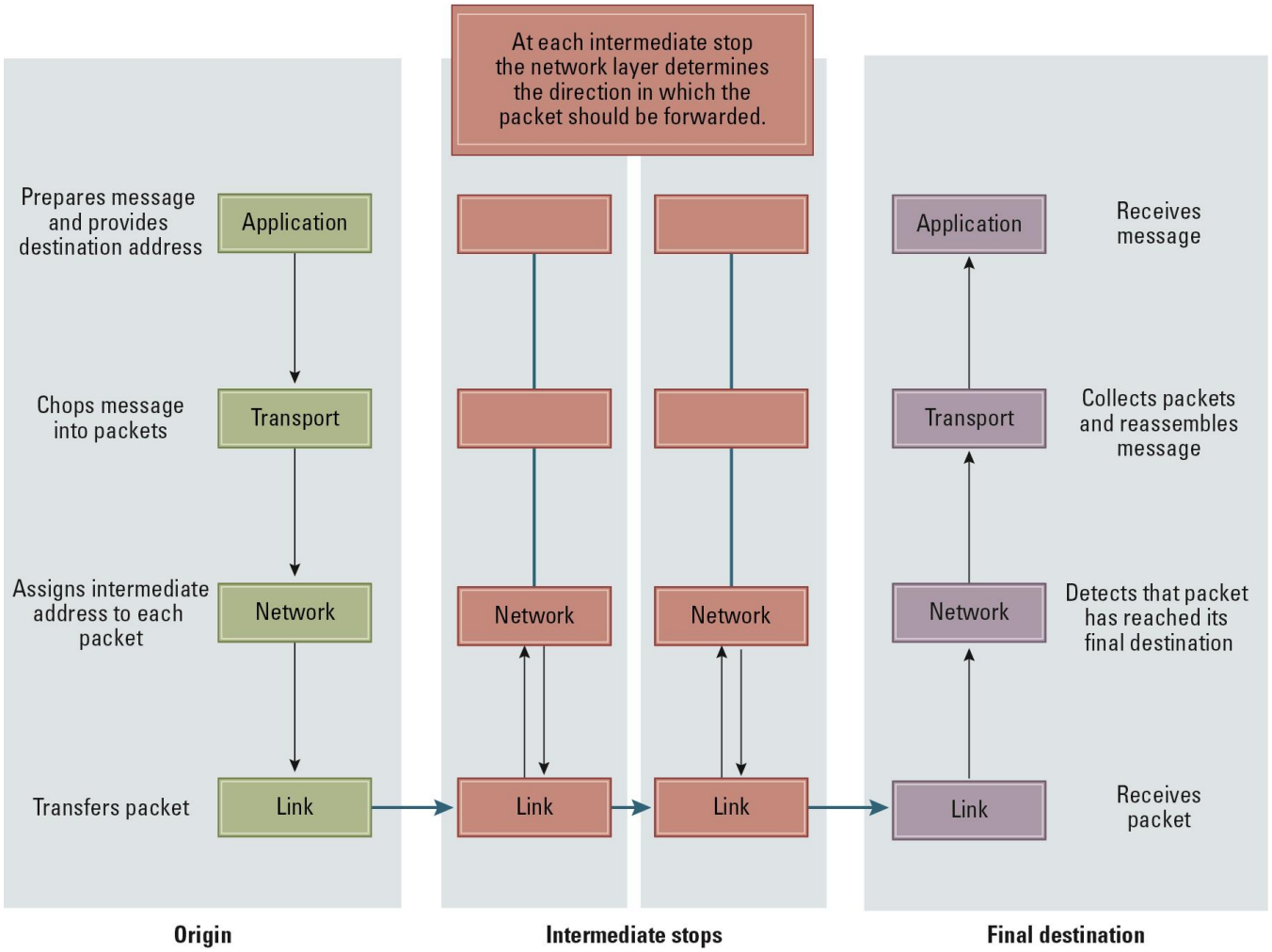
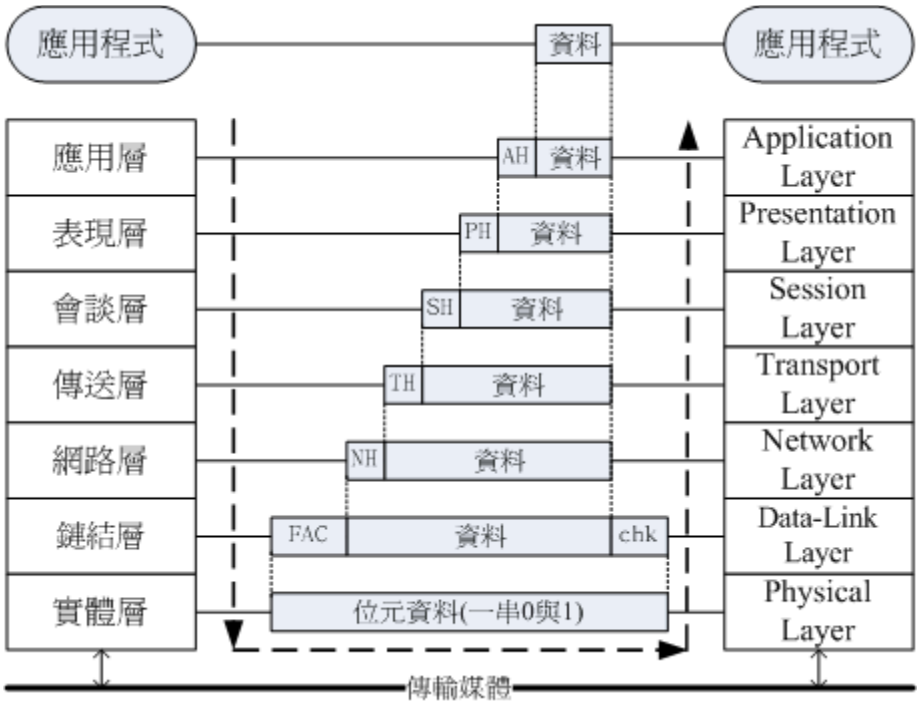
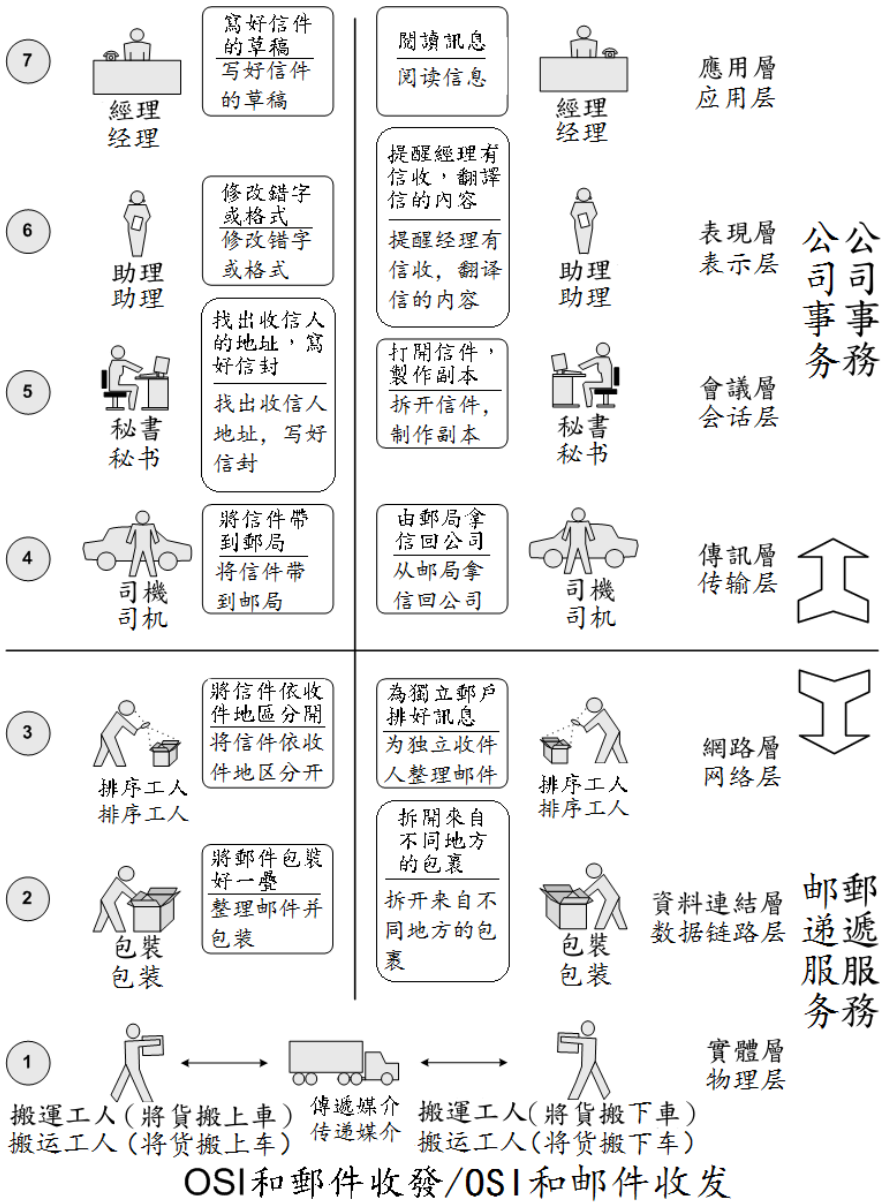


Figure 4.14 Following a message through the Internet





TCP/IP Protocol Suite

- Transport Layer
  - Transmission Control Protocol (TCP)
  - User Datagram Protocol (UDP)
- Network Layer
  - Internet Protocol (IP)
    - IPv4
    - IPv6

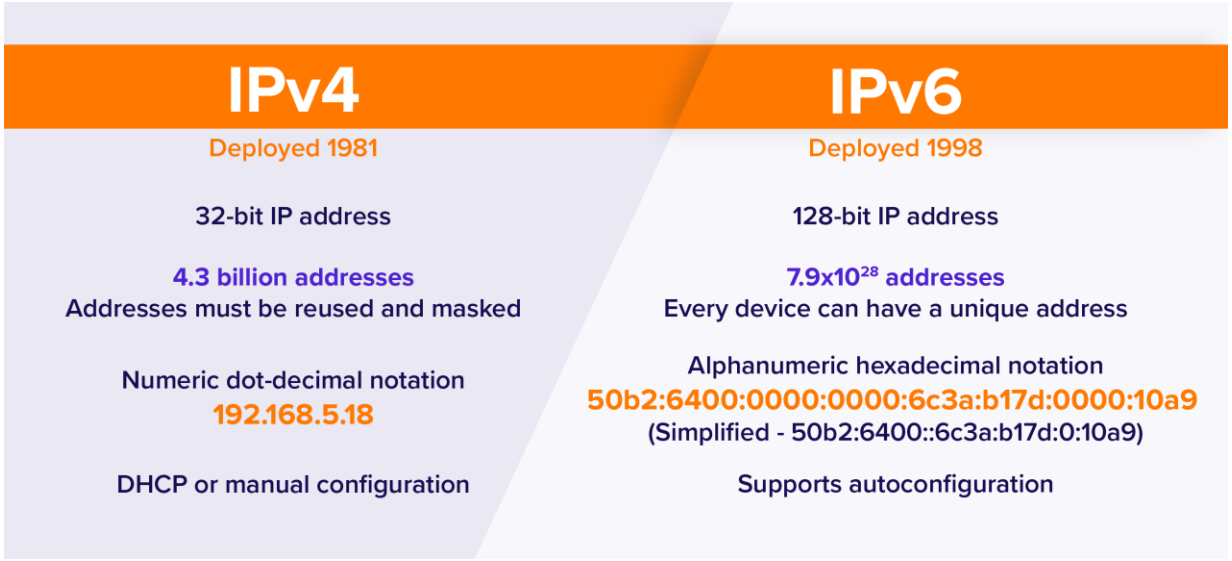
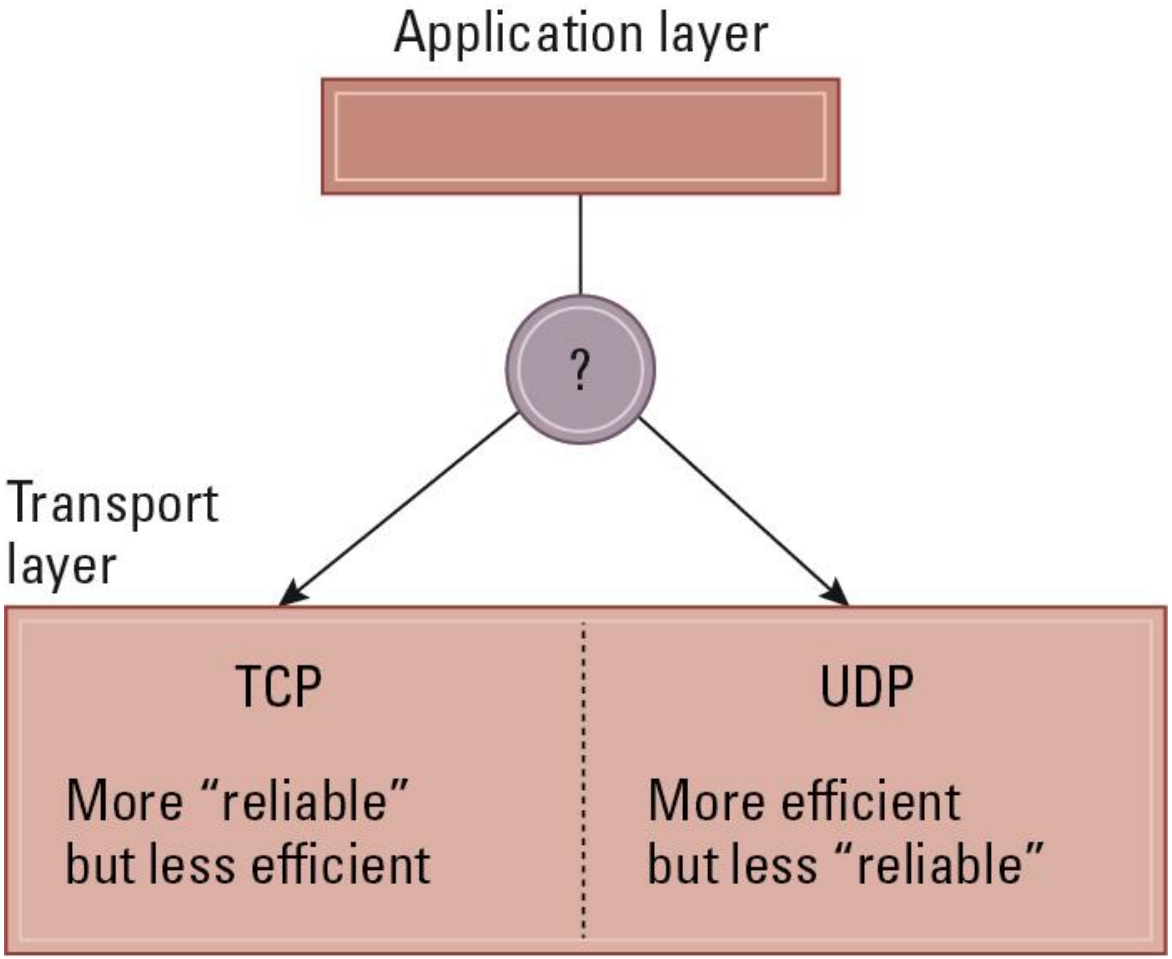
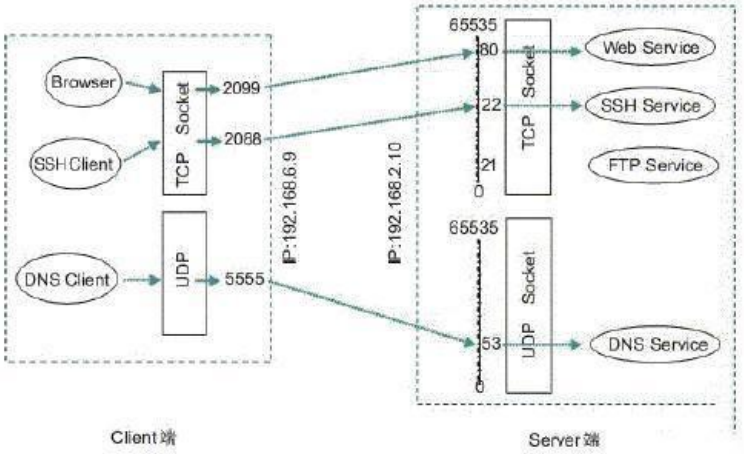


Figure 4.15 Choosing between TCP and UDP



4.5 Simple Client Server Program

- Socket: an abstraction for processes at the application layer to connect to the network via the transport layer
  - Needs to know
    - Source Address name (localhost)
    - Source Port number(1023…65535)
    - Destination Address
    - Destination Port number



Port #	Application Layer Protocol	Type	Description
20	FTP	TCP	File Transfer Protocol - data
21	FTP	TCP	File Transfer Protocol - control
22	SSH	TCP/UDP	Secure Shell for secure login
23	Telnet	TCP	Unencrypted login
25	SMTP	TCP	Simple Mail Transfer Protocol
53	DNS	TCP/UDP	Domain Name Server
67/68	DHCP	UDP	Dynamic Host
80	HTTP	TCP	HyperText Transfer Protocol
123	NTP	UDP	Network Time Protocol
161,162	SNMP	TCP/UDP	Simple Network Management Protocol
389	LDAP	TCP/UDP	Lightweight Directory Authentication Protocol
443	HTTPS	TCP/UDP	HTTP with Secure Socket Layer

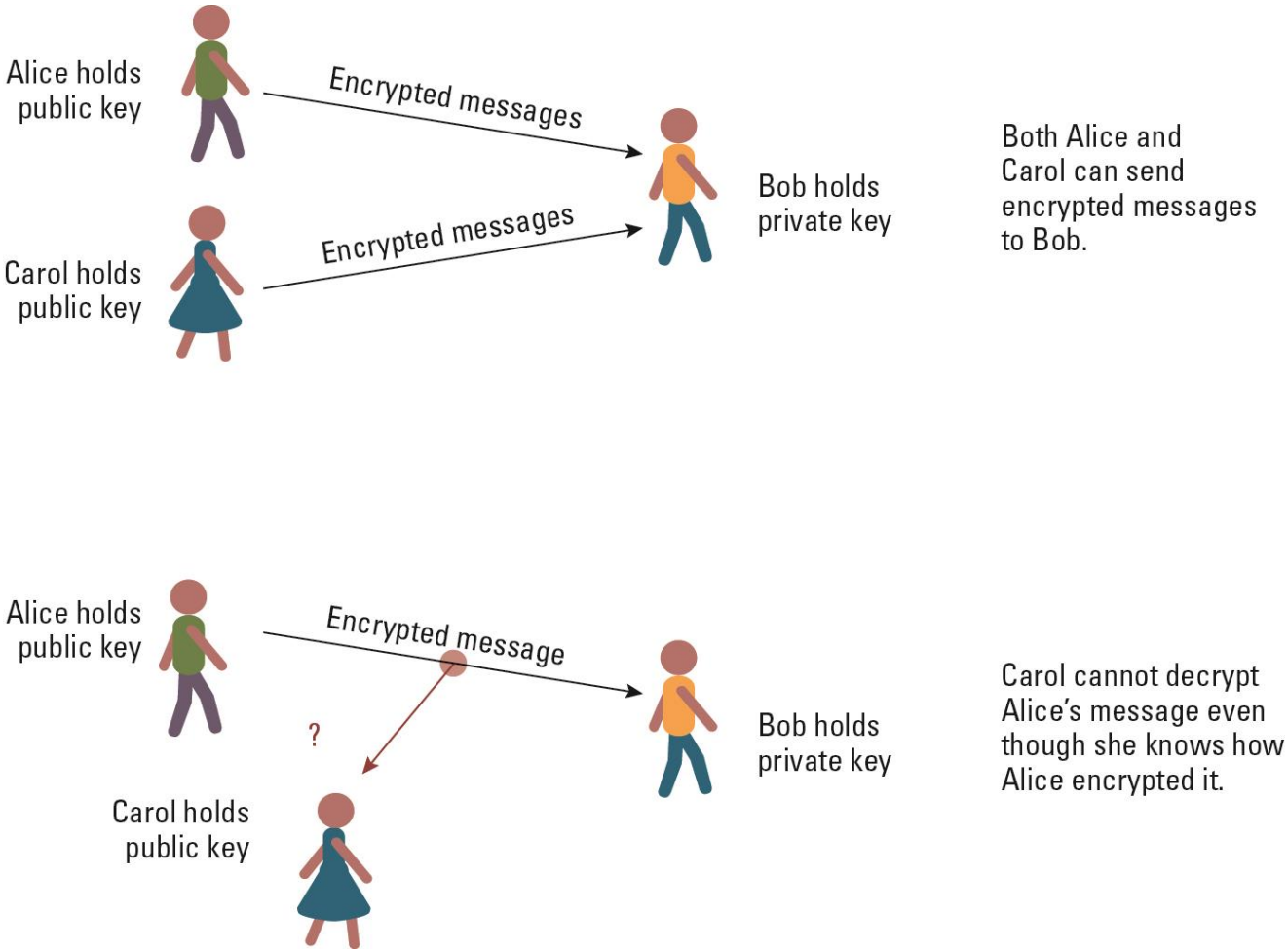
4.6 Cybersecurity

- Forms of Attack
  - Malware (viruses, worms, Trojan horses, spyware, phishing software)
  - Denial of service (DoS)
  - Spam (common medium for delivering malware)
- Protection and Cures
  - Firewalls
  - Spam filters
  - Proxy Servers
  - Antivirus software

Cryptography

- HTTPS for secure Internet access
- Public-key Encryption (asymmetric)
  - Public key: Used to encrypt messages
  - Private key: Used to decrypt messages
- Certificate Authorities
  - Trusted to maintain lists of public keys
  - Provide Certificates to clients containing a party's name and its public key

Figure 4.16 Public key encryption



Legal Approaches to Network Security

- Computer Fraud and Abuse Act
- Electronic Communication Privacy Act
- USA PATRIOT Act
- Communications Assistance for Law Enforcement Act
- Anticybersquatting Consumer Protection Act